

PRESENT STATUS AND TRENDS IN INVESTIGATION OF THE HUMAN  
CARDIOVASCULAR SYSTEM IN SPACE FLIGHTS

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According to Soviet and American data, subsequent to flights the most clearly expressed changes are in the cardiovascular system. Such changes are noted after both brief (N. M. Sisakyan, P. V. Buinov, et al, 1966) and particularly prolonged flights, when on the first day after return to earth collaptoid states may develop when orthostatic tests are made (Dietlein, Judy, 1966). However, under flight conditions and with a relative rest after the flights, using these methods it was impossible to detect significant changes or these changes, except for clearly expressed stressed states, were relatively small and not clearly expressed (O. G. Gazenko, 1964; R. M. Bayevskiy and O. G. Gazenko, 1964; N. M. Sisakyan, 1965; M. M. Link, 1965; Berry, et al, 1966).

Taking into account the great importance of the normal functioning of the cardiovascular system for maintaining a good overall feeling of well-being and a high work capacity in man, and also the prospects for prolonged space expeditions and the impossibility of an immediate return of the cosmonauts to earth, it is desirable to introduce into such /2 flights more perfect methods for determining the functional state and the physical reserves of a cosmonaut. Ground experiments and flights of space crews reveal the reality of such proposals. The difficulties in implementing them are essentially of a practical nature, but the vigorous development and improvement of methods (L. B. Andreyev, 1961; V. I. Bol'shov and V. I. Smirnov, 1965; A. I. Zoloterev, 1967), as well as increasing technical capabilities (R. M. Bayevskiy, et al, 1963; Lincoln, Mangelsdorf, 1966; A. N. Lebedev), are encouraging.

A more complex problem is the choice of the methods and the most adequate space flight conditions because the experiments made on the ground give only some idea concerning the changes which may arise in the human body in space. A critical analysis of the methods used in space flights indicates the need for future registry of such indices as the electrocardiogram, phonocardiogram and seismocardiogram. The combination of these methods makes it possible to evaluate the state of functions of automatism, excitability and conductivity of the cardiac muscle and also the contractability of the myocardium. Determination of the duration of the individual phases of the cardiac cycle, the relation between the onset and end of the electrical and mechanical systole, and the amplitude of the cardiac tones may be used in a study of intracardiac hemodynamics and the determination of asynchronism in the operation of the right and left sides of the heart. 3

Methods for investigation of peripheral blood circulation apparently will be of great importance in the future study of cosmonauts aboard a spaceship. Successful attempts now have been made to measure arterial blood pressure on the "Voskhod" and "Gemini" spaceships. Being a logical continuation of the earlier initiated study of the cardiovascular system in space flight, measurement of arterial pressure to a considerable degree will broaden our ideas concerning the character and mechanisms of development of different changes in hemodynamics.

We made comparative evaluations of different methods for the investigation of arterial pressure. Unfortunately, it must be stated that all indirect methods, involving the cyclic feeding of air into a cuff, may be incapable of reflecting shades of change of pressure under such dynamic conditions as space flight. In order to measure arterial pressure aboard a spaceship it apparently will be worthwhile to develop special servosystems.

Many authors have mentioned the good prospects for using electroplethysmography during flights (R. M. Bayevskiy, 1965; Berry, 1964, and others). Obviously, it will be most effective to use electroplethysmograms for study of cerebral blood circulation, but valuable information also can be obtained in a study of blood flow in the extremities. 4

The ability to make periodic medical examinations of cosmonauts during flight will make it possible for them to be free of an excessive number of transducers and at the same time will make it possible to carry out a detailed study of different systems or organs. For this purpose it is deemed promising to develop multipurpose apparatus with sets of

transducers for different measurements which will be carried aboard the ship and put on by the cosmonaut himself. The program for study of the cardiovascular system must provide for the registry of such indices as arterial pressure, the electrocardiogram, phono- and seismocardiogram, kinetocardiogram, sphygmogram of the arteries of the elastic and muscular types, electroplethysmogram, and also, obviously, the parameters of metabolism and body temperature.

Methods for in-flight investigation of the minute volume of blood circulation, rate of blood flow, etc., are attractive but questionable due to their complexity and the unwieldiness involved.

The information to be gained in a complex examination may be illustrated using the example of study of the cardiovascular system when there is stimulation of the human vestibular apparatus.

Fig. 1 shows that in subject A with a clearly expressed vestibular-autonomic complex of symptoms there were considerable changes of the systolic and minute volumes of the blood (SV and MV) and peripheral vascular resistance (PR), as well as the rate of propagation of the pulse wave through the vessels of the elastic type and arterial pressure (AP). In subject B, who manifested no vestibular-autonomic complex of symptoms, the hemodynamic indices experienced some fluctuations, but there was no definite direction of the changes. Also of <sup>15</sup> interest are the changes of the hemodynamic indices of the third subject (Fig. 2). At the onset he experienced the same hemodynamic changes as in subject B, but then simultaneously with an attenuation of the hemodynamic changes the vestibular-autonomic complex of symptoms also disappeared.

As space flights continue and interplanetary expeditions are organized the need will arise for solving a number of purely clinical problems associated with the need for an early diagnosis and treatment of illnesses, including disorders of the cardiovascular system.

Since the reactivity of the body may change considerably under the influence of unfavorable space flight factors (duration of isolation, hypodynamia, etc.), the symptoms of illnesses probably will lose some important distinguishing characteristics.

In this situation an electrocardiographic examination (possibility of impairment of coronary blood circulation) may have to be supplemented by a number of additional investiga-

tions. For example, it may be necessary to determine the anticoagulation possibilities of the blood. Such methods as capillaroscopy, study of the pattern of the ocular fundus, etc., may prove very useful in detecting vascular neurosis.

Functional tests will be of great importance in a study of the cardiovascular system. We used tests with a carefully measured physical load and Valsalva's test. The first test is a load primarily for the greater circulatory system and the second primarily for the lesser circulatory system. The results give hope that the tests will be informative under space flight conditions as well.

In addition to the use of functional tests these investigations obviously are made in combination with others, and in particular, together with investigations of the functions of the central nervous system and work capacity. It also is necessary to make investigations using a complex method in relation to a daily regime, the work and rest schedule.

The implementation of these studies may serve as a basis for accomplishing automatic checking of the condition of cosmonauts in flight with the processing and evaluation of the registered parameters aboard the ship using a computer with the subsequent printout of conclusions and recommendations on the control panel in front of the cosmonaut on duty and periodic relaying of information on the condition of the crew to ground stations.

These measures apparently will be necessary in order to ensure the safety of space expeditions on long flights of great duration when ground methods for processing medical data will be unsuitable due to the difficulty of contact with the earth and the need for the crew to make immediate decisions.

In developing diagnostic symptom complexes there inevitably will be difficulties due to the limited volume of flight data and due to the difference of methodological procedures and the characteristics of the sensors. For this reason it probably will be desirable to standardize the research methods used and the methods employed for processing information, as well as the transducers and instruments. Standardization also would assist in the more extensive use of the methods of space medicine in clinical practice, which in turn would be an additional check on their effectiveness.

#### REFERENCES

Andreyev, L. B.: Kinetocardiography in the Clinical Study of Disorders of the Cardiovascular System (Kinetokardiografiya

- v klinike zabolevaniy serdechno-sosudistoy sistemy). Klinicheskaya Meditsina, 39, 5, 12-21.
- Bayevskiy, R. M.: Physical Methods in Cosmonautics (Fizicheskiye metody v kosmonavtike). Moscow, 1965.
- Bayevskiy, R. M., Bogdanov, V. V. and Zhdanov, A. M.: A Diagnostic Machine with the Direct Input of Data (Diagnosticheskaya mashina s neposredstvennym vvod informatsii), Biol. i Med. Elektronika, No. 3, 1963, p. 28.
- Bayevskiy, R. M. and Gazenko, O. G.: Reactions of the Human Cardiovascular System and Reactions in Animals Under Conditions of Weightlessness (Reaktsii serdechno-sosudistoy sistemy cheloveka i zhivotnykh v usloviyakh nevesomosti). Kosmicheskkiye Issledovaniya, Vol. 2, No. 2, 1964, pp. 307-319.
- Bol'shov, V. M. and Smirnov, V. I.: A New Contactless Method for Measuring Arterial Pressure in Man and Animals (Novyy beskontaktnyy metod izmereniya arterial'nogo davleniya u cheloveka i zhivotnykh). IN: Problems of Cardiovascular Pathology (Voprosy serdechnososudistoy patologii). Moscow, 1965, pp. 141-147.
- Buyanov, P. V., Kovalev, V. V., et al: Results of Pre-flight and Post-flight Medical Servicing of Crew Members of the Spaceship "Voskhod" (Rezultaty predpoletnogo i poslepoletnogo med. obsledovaniya chlenov ekipazha kosmicheskogo korablya "Voskhod"). Kosmicheskkiye Issledovaniya, 4, 1, 1966, pp. 151-155.
- Gazenko, O. G.: Medical Investigations on the Vostok and Voskhod Spaceships (Meditsinskiye issledovaniya na kosmicheskikh korablyakh Vostok i Voskhod). Report at the Third International Symposium on Biocronautics and Space Research, San Antonio, Texas, 16-18 November 1964.
- Zolotarev, A. I.: Investigations of the Human Blood Circulation Apparatus as a Cybernetic System (Issledovaniya apparata krovoobrashcheniya cheloveka kak kiberneticheskoy sistemy). Dissertation, Voronezh, 1967.
- Lebed', A. N.: An Electronic Apparatus for the Preliminary Analysis of Information from Biotelemetric Investigations (Elektronnoye ustroystvo dlya predvaritel'nogo analiza informatsii biotelemetricheskikh issledovaniy). Meditsinskaya Promyshlennost' SSSR, 1966, No. 3, pp. 47-50.
- Sisakyan, N. M. (editor): Second Group Space Flight and Some

Results of Flights of Soviet Cosmonauts on the "Vostok"  
Ships (Vtoroy gruppovoy kosmicheskiy polet i nekotoryye  
itogi poletov sovetskikh kosmonavtov na korablyakh "Vostok"),  
Moscow, 1965.

Note: Figure captions given on next page. Figures not included in bound text.

## FIGURE CAPTIONS

Fig. 1. Indices of hemodynamics for subjects A and B. With cumulative effect of Coriolis force: along horizontal axis -- recording time (in minutes), along vertical axis -- recorded indices and their values; MV -- minute volume of blood in liters; SV -- systolic volume in ml; FCC -- frequency of cardiac contractions per minute; PR -- peripheral resistance of arterial system in arbitrary units; VP -- velocity or rate of propagation of pulse wave through arteries of the elastic type in cm/sec; AP max, lat, mean, pulse -- arterial pressure in mm Hg.

Fig. 2. Indices of hemodynamics in subject C with cumulative effect of Coriolis force. Notations same as in Fig. 1.